AN2452
Application note

STW8110x evaluation board and graphical user interface

Application and scope

This application note describes the evaluation board (EVB) and the graphical user interface (GUI) of the STW81101, STW81102 and STW81103 multi-band RF frequency synthesizers (with integrated VCOs).

The STW8110x GUI software allows the STW81101, STW81102 and STW81103 synthesizers to be programmed via an I^2C/SPI control interface.

Three evaluation boards are available depending on the output matching network optimal frequency range:

- EVB1G (single output - 1 GHz - output divider by 4)
- EVB2G (single output - 2 GHz - output divider by 2)
- EVB4G (single output - 4 GHz - direct output)

Contents

1 Software 3

1.1 Installation 3

1.2 Main form 3

1.3 Tutorial operation mode form 8

1.4 Waveform viewer 9

2 Evaluation board 10

2.1 Setup 10

2.2 Description 11

2.2.1 Top view 11

2.2.2 Bottom view 12

2.3 Schematics 13

2.4 Layout 16

2.5 Bill of materials 16

3 Revision history 20

1 Software

1.1 Installation

The STW8110x GUI software is built on the Microsoft (R) .NET Framework (see *http://www.microsoft.com/net/default.mspx*). It may require the installation of the Microsoft (R) .NET Framework version 2.0, which may require the installation of Windows Installer 3.0 (see *http://msdn.microsoft.com/library/default.asp?url=/library/en-us/msi/setup/windows_installer_start_page.asp*). Administrator privileges are required to install Microsoft (R) .NET Framework and Windows Installer.

Follow these steps to install the STW8110x GUI:

1. If an old version of the GUI is already installed, uninstall it.
2. Run *setup.exe* (datasheets, programming configuration files and desktop/quick launch shortcuts are optional components installed by default).
3. Run *STW8110xGUI.exe*
4. The default starting operation mode is Tutorial. The starting operation mode can be modified by means of the radio buttons in the tutorial form:
   a) Tutorial: a brief tutorial on the features of the GUI.
   b) Basic: only the main options are enabled.
   c) Advanced: all the available options are enabled.

1.2 Main form

This section details the items on the main form. See *Figure 1: Main form* on page 4.

1. Pressing this button shows the **About STW8110xGUI** screen.
2. Pressing this button opens the datasheet of the selected device.
3. Help
4. Device selection (STW81101/2/3).
5. GUI operation modes:

   Tutorial: A brief tutorial on the basic features of the GUI. An inner default configuration is loaded.

   Basic: only the main options are enabled. Frequency values must be set in the following order:

   a) Input reference frequency F_{ref}.
   b) Output frequency step F_{step}.
   c) Output frequency F_{out}.

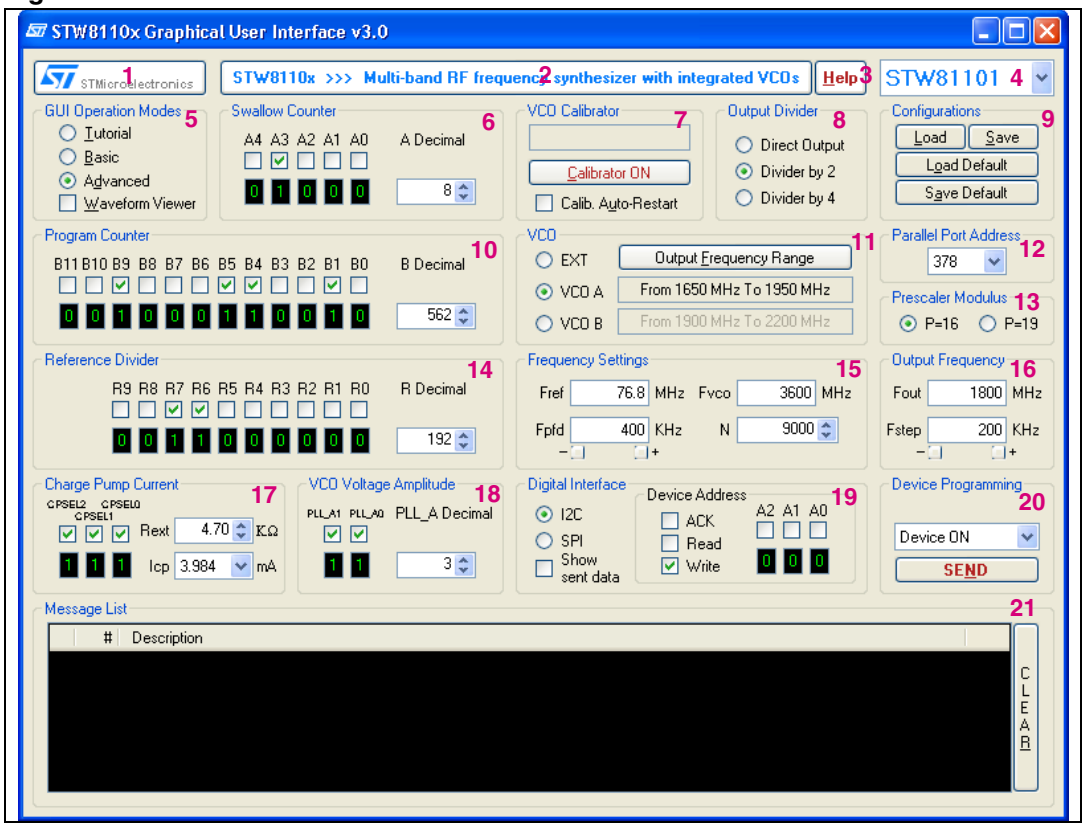
   The calibrator is always ON. VCO and output divider are set automatically.

   Advanced: all the available options are enabled. Any F_{vco} or F_{out} are allowed. A message will warn if the inserted values are beyond the frequency limits of the VCOs. Frequency values must be set in the following order:

   a) Input reference frequency F_{ref}.
   b) Output frequency step F_{step} or F_{pfd}.
   c) Output frequency F_{out} or F_{vco}.

   Waveform Viewer: a form is opened displaying the bit sequence sent to the device.

Figure 1. Main form



6. Swallow counter A: 5-bit counter.
7. VCO calibrator:
   - Last calibration F_{vco}: contains the last calibration data (VCO and frequency of calibration).
   - Calibrator ON/OFF.
   - The maximum allowed F_{pfd} during calibration is 1 MHz. If $F_{pfd} > 1$ MHz, the device is programmed in two steps:

     a) Device is programmed forcing calibration with the maximum $F_{pfd} \leq 1$ MHz ($F_{pfd} = F_{ref} / R \leq 1$ MHz ==> $R \geq F_{ref} / 10^6$).

     b) Device is programmed with the desired F_{pfd}.

     Example with F_{ref} = 76.8 MHz:

     Desired values:

     - F_{pfd} = 1200 kHz
     - $R = F_{ref} / F_{pfd} = 64$

     Forced values:

     - $R' = \lceil F_{ref} / 10^6 \rceil = \lceil 76.8 \rceil = 77$
     - $F'_{pfd} = F_{ref} / R' = 997.403$ kHz

     Device programming in two steps:

     a) Device is programmed with F_{pfd} = 997.403 kHz and Calibrator ON.

     b) Device is programmed with F_{pfd} = 1200 kHz and Calibrator OFF.

8. Output divider:
   - Direct output.
   - Divider by 2.
   - Divider by 4.
9. Configurations:
   - Load/Save: load/save a configuration file.
   - Load default/Save default: load/save a default configuration.
10. Program counter B: 12-bit counter.
11. VCO. VCO settings:
   - Output frequency range/VCOs frequency range: press this button to show information on the limits of F_{out}/F_{vco} (only for the embedded VCOs).
   - VCO selection (enabled only in Advanced mode):

     - EXT: external VCO. The external VCO buffer is able to manage a signal coming from an external VCO in order to build a synthesizer using the STW8110x only as PLL IC. The external VCO signal can range from 625 MHz up to 5 GHz. Its minimum power level must be -10 dBm.

     - VCO A/VCO B: embedded VCOs.
12. Parallel port address. Hex value of the parallel port base address:
   - 278: normally assigned to LPT2.
   - 378: normally assigned to LPT1.
   - 3BC
   - FILE: output is saved to a text file.
13. Prescaler modulus:
   - P=16
   - P=19
14. Reference divider. The 10-bit programmable reference counter allows the input reference frequency to be divided to produce the input clock to the phase frequency detector (PFD):

   $F_{pfd} = F_{ref} / R$

   where
   - F_{pfd}: PFD input frequency
   - F_{ref}: input reference frequency

   Limits: $2 \leq R \leq 1023$
15. Frequency settings:
   - F_{ref}: input reference frequency (MHz)

     - Limits: 10 MHz $\leq F_{ref} \leq$ 200 MHz
   - F_{pfd}: phase frequency detector (PFD) input frequency (kHz)

     $F_{pfd} = F_{ref} / R$, where R is the reference divider factor.
   - -/+: finds a lower/higher rational value for F_{pfd}.
   - F_{vco}: VCO oscillating frequency (MHz)

     $F_{vco} = N \cdot F_{pfd}$.
   - N: PLL division ratio

     $N = B \cdot P + A$.

16. Output frequency settings:
    - F_{out}: output frequency (MHz)

      $F_{out} = F_{vco} / DIV$, where DIV is the output division ratio.
    - F_{step}: output frequency step (kHz)

      $F_{step} = F_{pfd} / DIV$, where DIV is the output division ratio.
    - -/+: finds a lower/higher rational value for F_{step}.
17. Charge pump current. The nominal value of the output current is controlled by an external resistor (R_{ext}) and can be varied over 8 levels by means of 3 dedicated programming bits:
    - CPSEL[2:0]: bits controlling the charge pump current
    - R_{ext}: the minimum value of the current is:

      $I_{min} = 2\ V_{bg} / R_{ext}$ where $V_{bg} = 1.17$ V.
    - I_{cp}: charge pump current (mA)

      $I_{cp} = (CPSEL + 1) \cdot I_{min}$
18. VCO voltage amplitude. The voltage swing of the VCOs can be adjusted over 4 levels by means of two dedicated programming bits:
    - PLL_A[1:0]: bits controlling the voltage swing of the VCO.

      This setting trades current consumption with the VCO's phase noise performances. Higher amplitudes provide better phase noise, whereas lower amplitudes save power.
19. Two digital interfaces are available:
    - I^2C

      - ACK: if checked and the acknowledge is not received, read and write operations fail. Uncheck this if the board is not enabled to read.

      - Read: read the read-only register.

      - Write: write the 6 write-only registers.

      - A[2:0]: the device address ($1100A_2A_1A_0$) must be set.
    - SPI

    Show sent data: the programming sequence is shown on the message list.
20. Device programming:
    - Device programming modes:

      - Device ON: device on with output buffer control disabled.

      - Out Buffer CTRL: device on with output buffer control enabled. This control mode allows to enable/disable the output stage by a hardware control pin (EXT_PD, pin 23) while the PLL stays locked at the desired frequency; in such a way a very fast switching time is achieved. This feature can be useful in designing a ping-pong architecture saving the cost of an external RF switch.

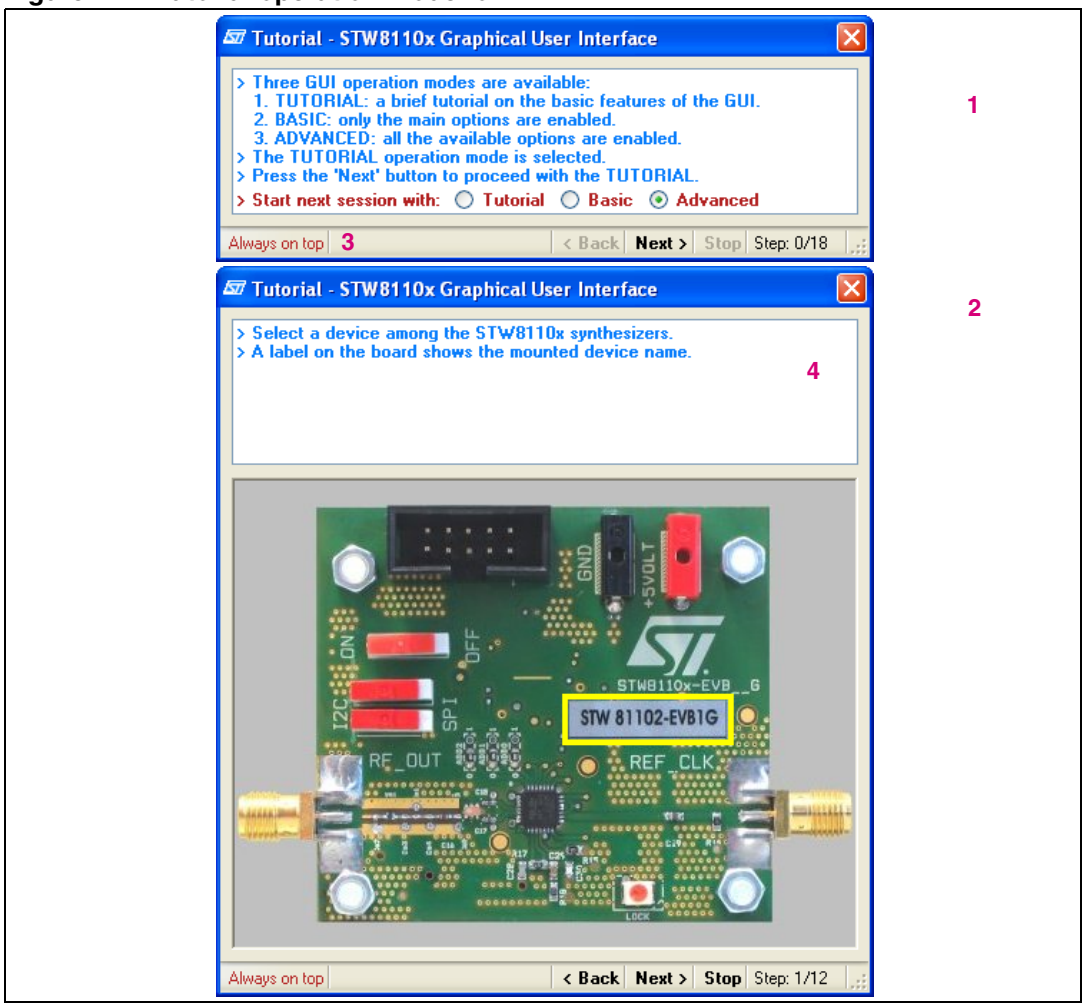
      - Power Down: 'Power Down' mode enabled (device off).
    - **SEND**: press this button to program the device.

21. Message list: displays information, warnings and errors:
    - **CLEAR**: press this button to delete all the messages.

    Clicking the right mouse button on the message list shows a menu:
    - Copy: copy the selected messages to the clipboard.
    - Copy to File: copy the selected messages to a file.
    - Append Mode: file is opened in append mode when 'Copy to File' is used.
    - Select All: all messages are selected (double-clicking the left mouse button has the same effect).
    - Deselect All: no message is selected.
    - Clear after Send: clears the message list after pressing the Send button.

1.3 Tutorial operation mode form

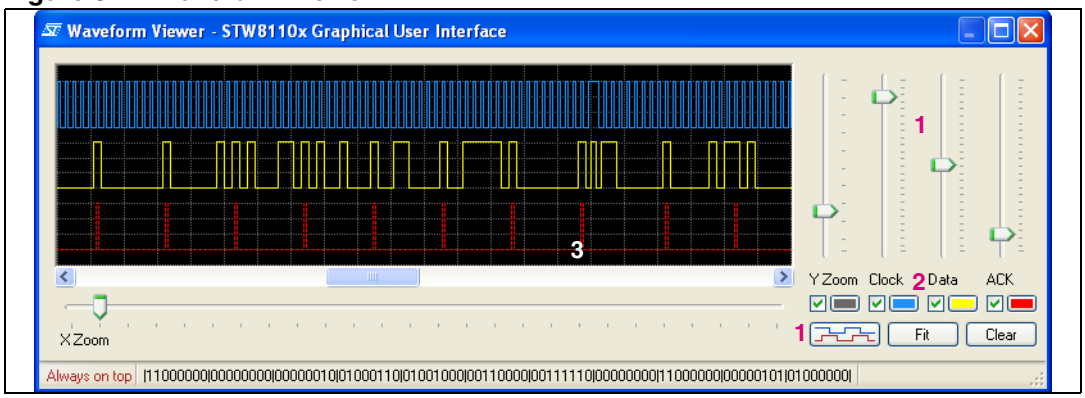
Figure 2. Tutorial operation mode form


Tutorial - STW8110x Graphical User Interface
> Three GUI operation modes are available:
1. TUTORIAL: a brief tutorial on the basic features of the GUI.
2. BASIC: only the main options are enabled.
3. ADVANCED: all the available options are enabled.
> The TUTORIAL operation mode is selected.
> Press the 'Next' button to proceed with the TUTORIAL.
> Start next session with: Tutorial Basic Advanced
Always on top
3
< Back
Next >
Stop
Step: 0/18
1
Tutorial - STW8110x Graphical User Interface
> Select a device among the STW8110x synthesizers.
> A label on the board shows the mounted device name.
4
STW 81102-EVB1G
Always on top
< Back
Next >
Stop
Step: 1/12
2

1. Help for the current GUI operation mode.
2. Start next session with: select the operation mode for the next session.
3. Always on top:
   - Red: enabled
   - Gray: disabled
4. The tutorial form shows a description of the evaluation board.

1.4 Waveform viewer

Figure 3. Waveform viewer



The digital signals used to program the device can be displayed on a waveform viewer:

- I^2C - the following are shown:
  - SCL (clock) signals sent to the device
  - SDA (data) signals sent to the device
  - ACK signals sent from the device
- SPI - the following signals are shown:
  - Clock
  - Data
  - Load

1. Traces can be arranged by means of the vertical sliders, or in two default positions (separated or superimposed traces) by means of a button.
2. The checkboxes allow you to display or hide the traces and bit descriptions that become visible when zooming in.
3. The mouse buttons have the following functions on the waveform display:
   - Left: zoom in
   - Right: zoom out
   - Middle: pan

2 Evaluation board

2.1 Setup

1. Connect the evaluation board to the PC parallel port via the cable included in the kit.
2. Choose which digital bus is used: the SPI or I^2C.
3. If the I^2C is set, the device address must be chosen by connecting ADD [2:0] to VCC (1) or GND (0). The default is 000.
4. Connect a signal generator to the REF_CLK connector (external reference clock). Set the frequency as desired (13 MHz, 19.2 MHz, 76.8 MHz,…) and set the level to 10 dBm.
5. Connect the RF OUT connector to a spectrum analyzer.
6. Make sure that the device is not in hardware power-down (that is, ensure the switch is not in the off position).

The lock detector LED is turned on when the device is locked.

The nominal value of the charge pump output current is controlled by the external resistor R15 (4.7 kΩ on the evaluation board).

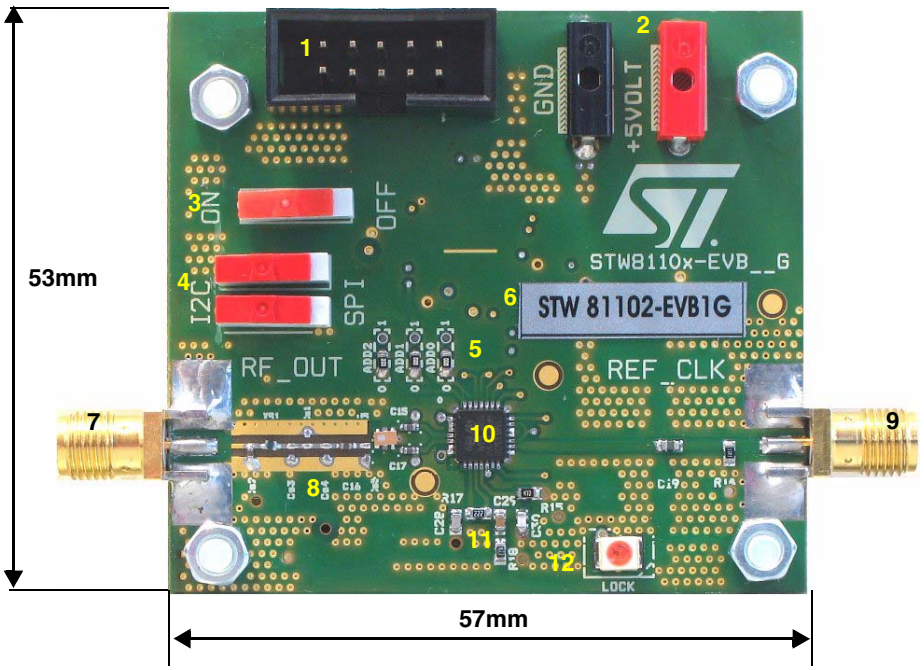
The loop filter components are: C28, R17, R18, R18, C25, C30.

The output matching network can be adjusted, depending on the application.

2.2 Description

2.2.1 Top view

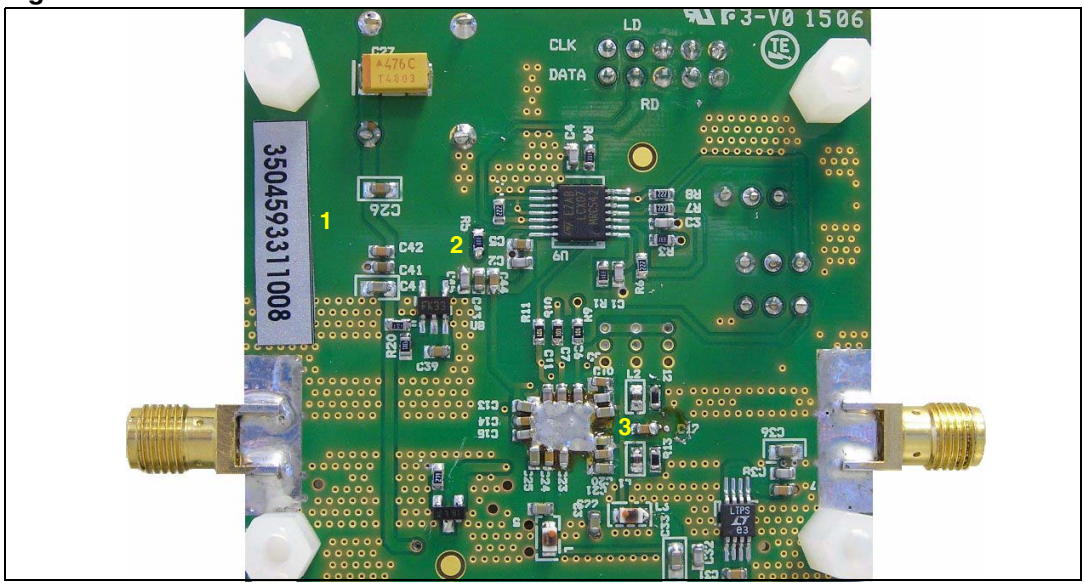
Figure 4. STW8110x EVB (1G/2G/4G): top view



1. Digital interface connector: connect to the PC parallel port through the supplied cable.
2. Power supply (5 V).
3. Hardware power down: turn on/off the device.
4. Digital interface selection between I^2C and SPI.
5. I^2C device address (default: 000).
6. Identification label. Two ID labels are present on the board network (see also *2.2.2* - 1):
   single output EVB top: STW8110x-EVBy,
   bottom: aaaaaaaaxyzzz, where:
   - aaaaaaaa = internal ST code
   - x = 1,2,3 depending on the device (STW81101/2/3)
   - y = 1,2,4 depending on the board (EVB1G/2G/4G)
   - zzz = progressive board number
7. RF output.
8. Single output EVB: RF output matching network (see also *2.2.2* - 3 and *Figure 6*).
   Differential output EVB: RF output de-coupling capacitors (C46 and C47).
9. Reference clock input.
10. STW8110x.
11. Loop filter and external resistor controlling the charge pump current (R15).
12. Lock detector LED.

2.2.2 Bottom view

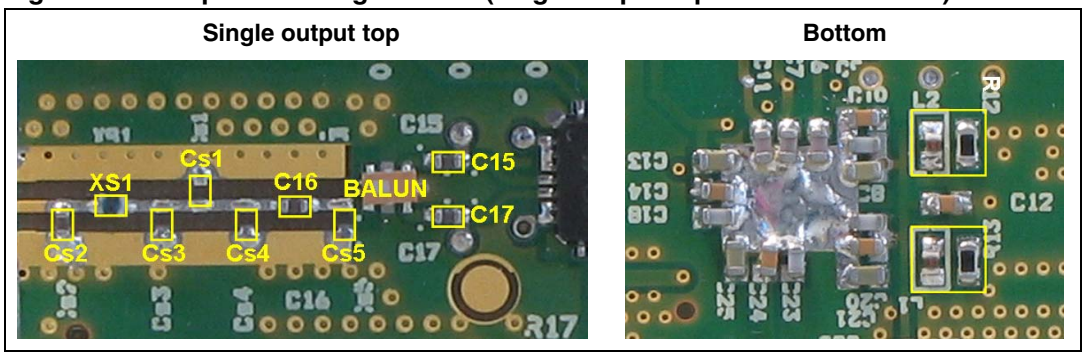
Figure 5. STW8110x evaluation board bottom view



The bottom view (with the exception of the SMA connectors) is common to both the single and the differential output evaluation boards.

1. Identification label (see *2.2.1* - 6).
2. The R5 short enables the I^2C read mode.
3. RF output matching network (L1, R13, L2, R12) - (see *2.2.1* - 8 and *Figure 6*).

Figure 6. Output matching network (single output top and bottom views)



2.3 Schematics

Figure 7. Main schematic

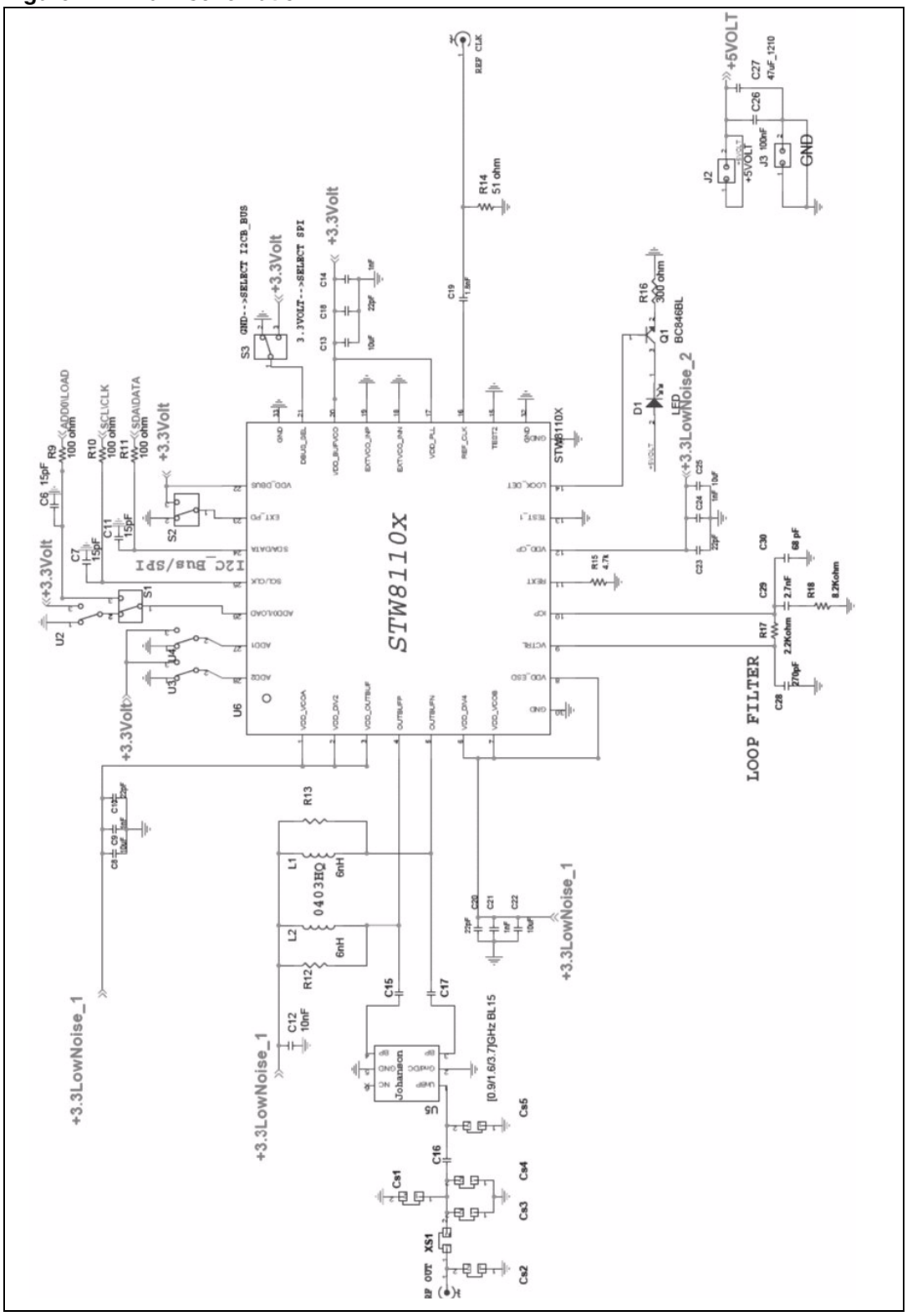


Figure 8. Digital interface

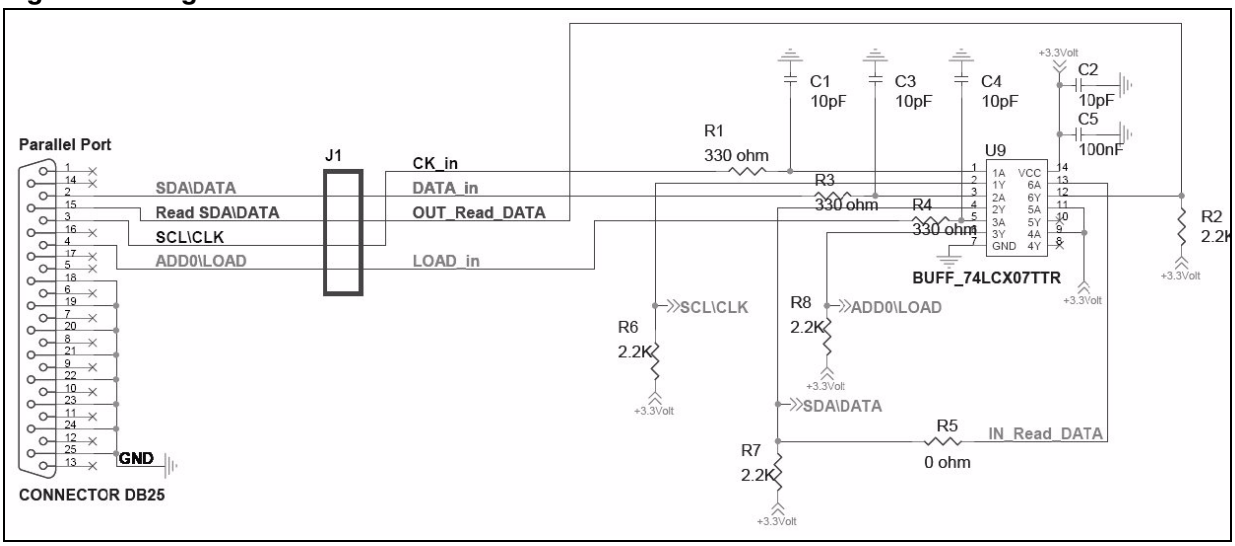


Figure 9. Low noise voltage regulator

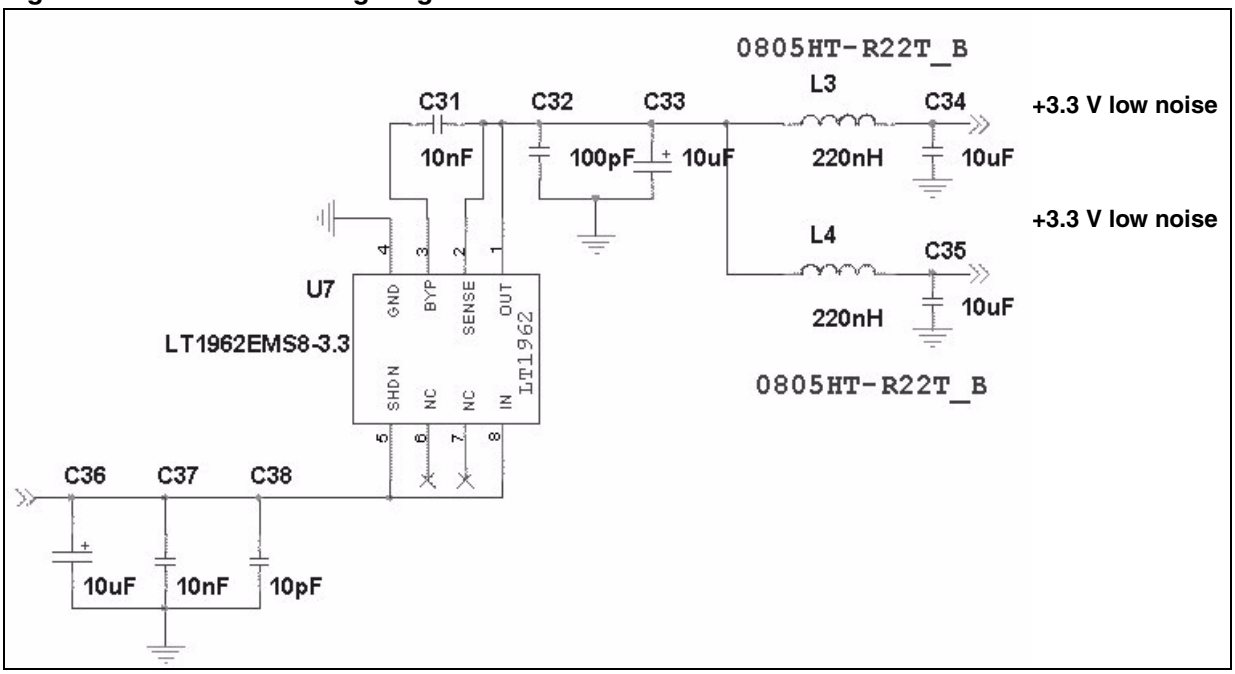
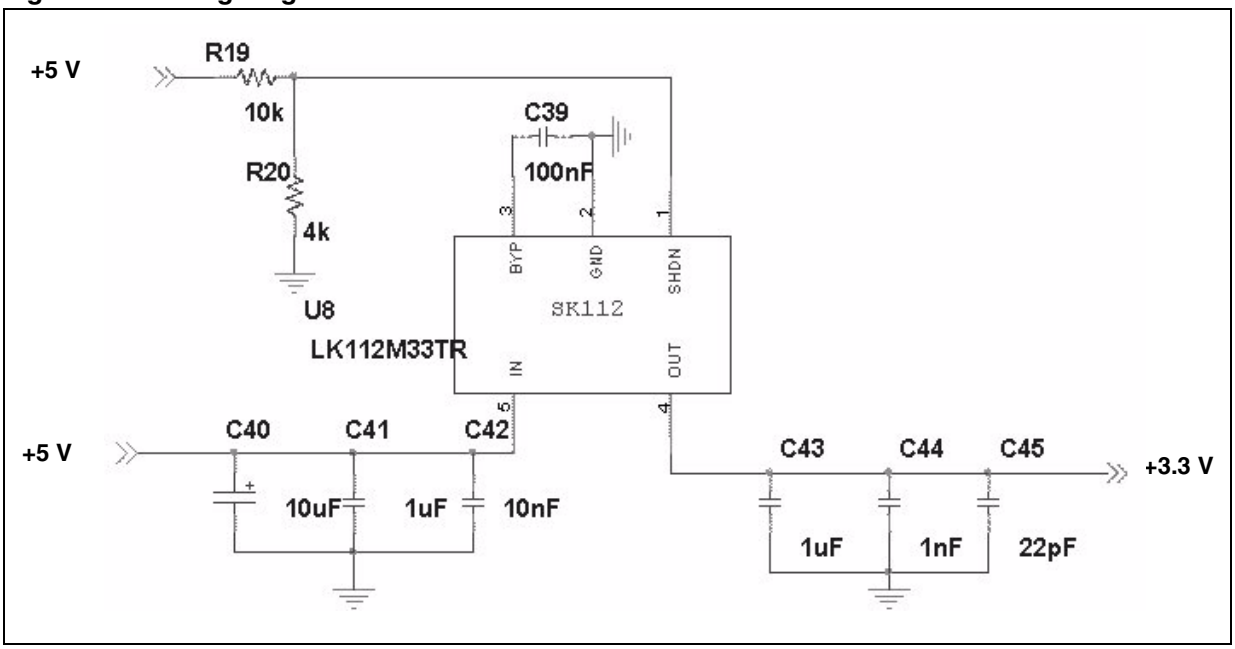


Figure 10. Voltage regulator



2.4 Layout

Figure 11. Top layer

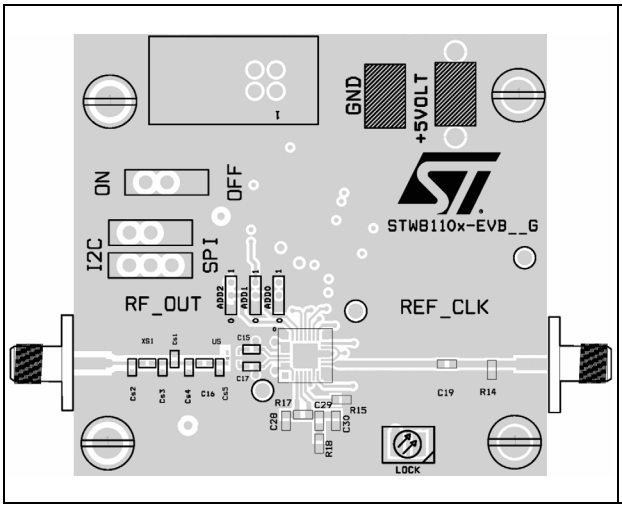


Figure 12. Bottom layer

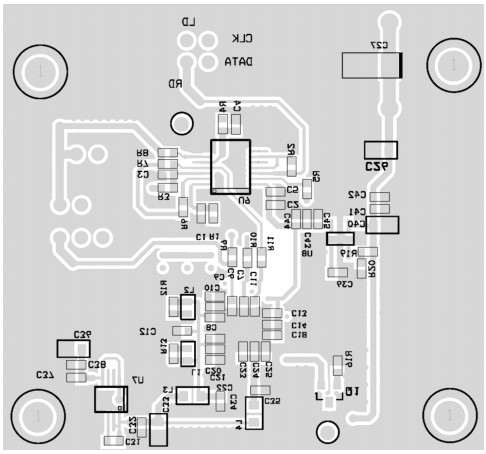


Figure 13. Ground layer

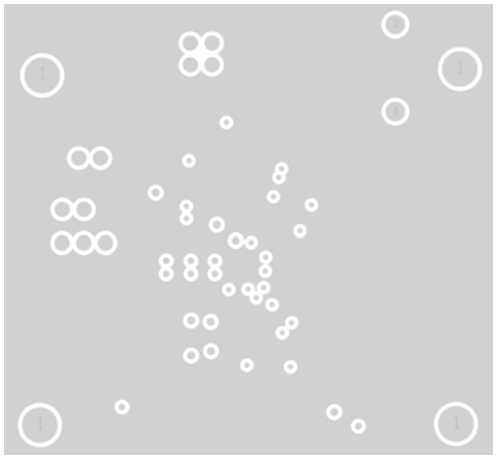
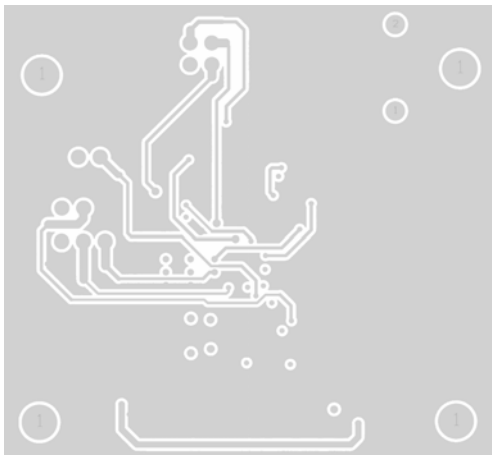


Figure 14. Power layer



2.5 Bill of materials

Table 1. Bill of materials common to all the EVBs (EVB1G/2G/4G)

Quantity	Reference	Part	Part number - manufacturer
3	R1, R3, R4	330 Ω	0603 - PHICOMP
5	R2, R6, R7, R8, R17	2.2 kΩ	0603 - PHICOMP
1	R5	0 Ω	0603 - PHICOMP
3	R9, R10, R11	100 Ω	0603 - PHICOMP
1	R14	51 Ω	0603 - PHICOMP
1	R15	4.7 kΩ	0603 - PHICOMP

Table 1. Bill of materials common to all the EVBs (EVB1G/2G/4G) (continued)

Quantity	Reference	Part	Part number - manufacturer
1	R16	270 Ω	0603 - PHICOMP
1	R18	8.2 kΩ	0603 - PHICOMP
1	R19	10 kΩ	0603 - PHICOMP
1	R20	4 kΩ	0603 - PHICOMP
9	C8, C13, C22, C25, C33, C34, C35, C36, C40, C35, C36, C40	10 F	GRM188 - 0603 - Murata
5	C1, C2, C3, C4, C38	10 pF	GRM188 - 0603 - Murata
3	C6, C7, C11	15 pF	GRM188 - 0603 - Murata
3	C5, C26, C39	100 nF	GRM188 - 0603 - Murata
5	C10, C18, C20, C23, C45	22 pF	GRM188 - 0603 - Murata
6	C9, C12, C14, C21, C24, C44	1 nF	GRM188 - 0603 - Murata
1	C19	1.8 nF	GRM188 - 0603 - Murata
1	C28	270 pF	GRM188-COG - 0603 - Murata
1	C30	68 pF	GRM188-COG - 0603 - Murata
1	C29	2.7 nF	GRM188-COG - 0603 - Murata
1	C27	47 F	1210 - AVX TPS Series III
3	C31, C37, C42	10 nF	GRM188 - 0603 - Murata
1	C32	100 pF	GRM188 - 0603 - Murata
2	C41, C43	1 F	GRM188 - 0603 - Murata
2	L3,L4	220 nH	0805HT- R22T B - Coilcraft
3	U2, U3, U4	0 Ω	0603 - PHICOMP
1	D1	LED	
1	Q1	BC847C	ST
1	U6	STW8110x	ST
1	U7	LT1962EMS8-3.3	Linear Technology
1	U8	LK112M33TR	ST
1	U9	74LCX07TTR	ST
1	SMA (1.6mm)	SMA REF Freq	
1	SMA (1.6mm)	SMA Band 2	
1	J1	10 pole connector	
1	J2	+5VOLT	
1	J3	GND	
3	S1, S2, S3	Switch	

Table 2. EVB1G output matching network

Quantity	Reference	Part	Part number - manufacturer
1	Cs2	0.5 pF	GRM1555C1HR50C - MURATA
1	XS1	2.1 nH	0403HQ-2N1XJL - COILCRAFT
	Cs3	NC	
	Cs1	NC	
	Cs4	NC	
	Cs5	NC	
1	C16	22 pF	GRM1555C1H220J - MURATA
1	U5	0900BL15	0900BL15C050 - JOHANSON
2	C15, C17	8.2 pF	GRM1555C1H8R2D - MURATA
2	R12, R13	24.9 Ω	
2	L1, L2	18 nH	0403HQ-18NXJL- COILCRAFT

Table 3. EVB2G output matching network

Quantity	Reference	Part	Part number - manufacturer
	Cs2	NC	
1	XS1	1.9 nH	0402PA-1N9X B - COILCRAFT
1	Cs3	1.2 pF	GRM1555C1H1R2C - MURATA
	Cs1	NC	
	Cs4	NC	
	Cs5	NC	
1	C16	22 pF	GRM1555C1H220J - MURATA
1	U5	1600BL15	1600BL15B100 - JOHANSON
2	C15, C17	22 pF	GRM1555C1H220J - MURATA
2	R12, R13	51 Ω	
2	L1, L2	5.5 nH	0403HQ-5N5XJL - COILCRAFT

Table 4. EVB4G output matching network

Quantity	Reference	Part	Part number - manufacturer
1	Cs2	1.2 pF	GRM1555C1H1R2C - MURATA
1	XS1	4.7 pF	GRM1555C1H4R7C - MURATA
1	Cs3	1.2 pF	GRM1555C1H1R2C - MURATA
	Cs1	NC	
1	Cs4	1 pF	GRM1555C1H1R0C - MURATA
1	Cs5	1 pF	GRM1555C1H1R0C - MURATA
1	C16	12 pF	GRM1555C1H120J - MURATA
1	U5	3700BL15	3700BL15B100 - JOHANSON
2	C15, C17	12 pF	GRM1555C1H120J - MURATA
2	R12, R13	51 Ω	
1	L1, L2	5.5 nH	0403HQ-5N5XJL - COILCRAFT

3 Revision history

Table 5. Document revision history

Date	Revision	Changes
17-Jul-2007	1	Initial release.
13-Aug-2007	2	Updated item 6 in *Section 2.2.1: Top view*.
15-Feb-2008	3	Modified *Section 1.2: Main form* and *Section 1.3: Tutorial operation mode form*. Added *Section 1.4: Waveform viewer*.

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